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National Eutrophication Survey, Corvallis, Oreg

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT

ON

LAKE DIVERSION

ARCHER AND BAYLOR COUNTIES

TEXAS

EPA REGION VI

WORKING PAPER NO. 642

WITH THE COOPERATION OF THE

TEXAS WATER QUALITY BOARD

AND THE

TEXAS NATIONAL GUARD

FEBRUARY, 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Texas Water Quality Board for professional involvement, to the Texas National Guard for conducting the tributary sampling phase of the Survey, and to those Texas wastewater treatment plant operators who voluntarily provided effluent samples.

Hugh C. Yantis, Jr., Executive Director of the Texas Water Quality Board, and John B. Latchford, Jr., Director, and the staff of the Field Operations Division provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General Thomas Bishop, the Adjutant General of Texas, and Project Officer Colonel William L. Seals, who directed the volunteer efforts of the Texas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of Texas

NAME	COUNTY
Amistad	Val Verde
Bastrop	Bastrop
Belton	Bell, Coryell
Braunig	Bexar
Brownwood	Brown
Buchanan	Burnet, Llano
Caddo	Harrison, Marion, TX; Caddo Parish, LA
Calaveras	Bexar
Canyon	Comal
Colorado City	Mitchell
Corpus Christi	Jim Wells, Live Oak, San Patricio
Diversion	Archer, Baylor
Eagle Mountain	Tarrant, Wise
Fort Phantom Hill	Jones
Houston	Harris
Kemp	Baylor
Lake O'The Pines	Camp, Marion, Morris, Upshur
Lavon	Collin
Lewisville (Garza-Little Elm)	Denton
Livingston	Polk, San Jacinto, Trinity, Walker

Lyndon B. Johnson	Burnet, Llano
Medina	Bandera, Medina
Meredith	Hutchinson, Moore, Potter
O. C. Fisher (San Angelo)	Tom Green
Palestine	Anderson, Cherokee, Henderson, Smith
Possum Kingdom	Palo Pinto, Stephens, Young
Sam Rayburn	Angelina, Jasper Nacogdoches, Sabine, San Augustine
Somerville	Burleson, Lee, Washington
E. V. Spence	Coke
Stamford	Haskell
Stillhouse Hollow	Bell
Tawakoni	Hunt, Rains, Van Zandt
Texoma	Cooke, Grayson TX; Bryan, Johnston, Love, Marshall, OK
Travis	Burnet, Travis
Trinidad	Henderson
Twin Buttes	Tom Green
White River	Crosby
Whitney	Bosque, Hill
Wright Patman (Texarkana)	Bowie, Cass

LAKE DIVERSION
Tributary Sampling Site
Lake Sampling Site
Scale
Dam Location

LAKE DIVERSION

STORET NO. 4812

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Lake Diversion is eutrophic; i.e., well supplied with nutrients and quite productive. Whether nutrient enrichment is beneficial or deleterious depends on the actual or potential effect on the uses of the lake. In this regard, no nuisance conditions are known to personnel of the Texas Water Quality Board and there is little or no impairment of the designated beneficial uses of this lake.

Lake Diversion ranked thirteenth in overall trophic quality when the 39 Texas reservoirs sampled in 1974 were compared using a combination of six water quality parameters*. Twelve of the reservoirs had less median total phosphorus, 11 had less and six had the same median dissolved orthophosphorus, six had less and one had the same median inorganic nitrogen, 27 had less mean chlorophyll a, and 26 had greater mean Secchi disc transparency.

Survey limnologists observed submerged and emergent macrophytes in the shallows near stations 1 and 2 in August, and blue-green algae were dominant in the August sample (page 6).

* See Appendix A.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Lake Diversion was phosphorus limited at the time the sample was taken (05/13/74). The lake data indicate phosphorus limitation in May and August but nitrogen limitation in October.

C. Nutrient Controllability:

1. Point sources--During the sampling year, septic tanks serving lakeshore residences were the only point sources impacting Lake Diversion. Total phosphorus loads from these sources were estimated to have amounted to 0.9% of the total to the lake; however, a shoreline survey would have to be done to determine the actual phosphorus contributions.

The present loading of 0.33 g/m^2/year at normal pool level is more than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as an oligotrophic loading but less than his proposed eutrophic loading; i.e., a mesotrophic loading (see page 11). However, the actual areal loading during the sampling year was greater than that because of low water levels and reduced area. The lake could not be sampled in March because of low water (the Survey limnologists estimated the lake volume was only 25% of normal capacity); and in October, the water level again was low because of drawdown to permit work on the dam (Gamble, 1974).

2. Non-point sources--Non-point sources contributed 99.1% of the total phosphorus load during the sampling year. The Wichita River contributed 81.8%, and Spring Creek contributed 2.6%. The ungaged minor tributaries and immediate drainage contributed an estimated 9.5%.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS[†]

A. Lake Morphometry[††]:

1. Surface area: 13.84 kilometers^2.
2. Mean depth: 3.7 meters.
3. Maximum depth: 10.7 meters.
4. Volume: 51,208 x 10^6 m^3.
5. Mean hydraulic retention time: 156 days (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Wichita River	5,402.7	3.710
Spring Creek	35.5	0.118
Minor tributaries & immediate drainage	258.9	0.430
Totals	5,697.1	4.258

2. Outlet -

South Side Canal	-	2.360
Wichita River	5,710.9**	1.432
Total	5,710.8	3.792

C. Precipitation***:

1. Year of sampling: 70.6 centimeters.
2. Mean annual: 69.1 centimeters.

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† Table of metric conversions--Appendix B.
†† Gamble, 1974.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Lake Diversion was sampled three times in 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two or more depths at three stations on the lake (see map, page vi). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 2.7 meters at station 1, 6.7 meters at station 2, and 8.2 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR STREAMFLOW AT
STREET CODE [illegible]

PARAMETER	1ST SAMPLING : 5/1/[illegible]			2ND SAMPLING : 6/ [illegible]			3RD SAMPLING [illegible]		
	3 SITES			3 SITES			3 SITES		
	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	23.1 - 25.7	25.3	25.4	25.3 - 26.2	25.9	25.8	15.7 - 17.3	16.8	17.2
DISS OXY (MG/L)	6.9 - 7.6	7.1	7.2	6.8 - 7.8	7.0	7.2	7.2 - 8.4	7.8	8.1
CHEM OXY (MG/KG)	497. - 498.	495.	498.	596. - 533.	566.	567.	233. - 486.	338.	487.
PH (STAND UNITS)	8.0 - 8.2	8.1	8.1	8.2 - 8.4	8.3	8.3			
TOT ALK (MG/L)	90. - 92.	91.	91.	70. - 72.	71.	70.	77. - 85.	79.	78.
TOT P (MG/L)	0.829 - 0.856	0.838	0.825	0.839 - 0.847	0.824	0.838	0.825 - 0.877	0.850	0.838
ORTHO P (MG/L)	0.884 - 0.917	0.899	0.899	0.887 - 0.897	0.892	0.892	0.821 - 0.834	0.827	0.826
NO2+NO3 (MG/L)	0.891 - 0.958	0.922	0.919	0.825 - 0.835	0.829	0.826	0.836 - 0.858	0.853	0.849
AMMONIA (MG/L)	0.940 - 0.999	0.977	0.986	0.838 - 0.862	0.844	0.846	0.835 - 0.868	0.839	0.838
KJEL N (MG/L)	0.460 - 1.298	0.535	0.460	0.460 - 0.780	0.478	0.460	0.388 - 1.278	0.483	0.459
INORG N (MG/L)	0.228 - 0.258	0.249	0.258	0.858 - 0.886	0.864	0.860	0.248 - 0.268	0.252	0.250
TOTAL N (MG/L)	0.468 - 1.358	0.542	0.538	0.428 - 0.726	0.567	0.478	0.529 - 1.388	0.737	0.438
CHLOPYL A (MG/L)	2.6 - 4.1	3.1	2.6	24.8 - 25.5	25.2	25.4	13.4 - 48.4	28.5	13.4
SECCHI (METERS)	0.3 - 1.8	0.7	0.4	1.8 - 2.2	2.1	1.8	0.8 - 0.9	0.9	0.8

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/13/74	1. Scenedesmus sp.	1,946
	2. Merismopedia sp.	579
	3. Oscillatoria sp.	483
	4. Cocystis sp.	386
	5. Chroomonas sp.	290
	Other genera	1,450
	Total	4,734
08/08/74	1. Aphanizomenon sp.	4,607
	2. Oscillatoria sp.	3,694
	3. Lyngbya sp.	1,470
	4. Merismopedia sp.	1,191
	5. Chroomonas sp.	367
	Other genera	1,470
	Total	12,789
10/28/74	1. Nitzschia sp.	1,444
	2. Oscillatoria sp.	903
	3. Cocystis sp.	650
	4. Diptonema sp.	289
	5. Chroomonas sp.	72
	Other genera	218
	Total	3,576

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
05/13/74	1	4.1
	2	2.6
	3	2.6
08/08/74	1	19.8
	2	22.8
	3	23.5
10/28/74	1	13.4
	2	13.6
	3	40.4

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l dry wt.)
Control	0.010	0.140	0.1
0.050 P	0.060	0.140	2.6
0.050 P + 1.0 N	0.060	1.140	14.7
1.0 N	0.010	1.140	0.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Lake Diversion was low at the time the sample was collected (05/13/74). Also, the significant increase in yield with the addition of phosphorus alone indicates the lake was phosphorus limited at that time. Note that the addition of nitrogen alone resulted in a yield no greater than that of the control.

The lake data indicate phosphorus limitation in May and August as well; i.e., the mean inorganic nitrogen to orthophosphorus ratios were 16 to 1 or greater at all sampling stations. However, nitrogen limitation is indicated in October (the mean inorganic nitrogen to orthophosphorus ratios were 7 to 1 or less at all stations, and nitrogen limitation would be expected).

IV. NUTRIENT LOADINGS
(See Appendix F for data)

For the determination of nutrient loadings, the Texas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi). Sampling was begun in September, 1974, and was completed in August, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Texas District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads for Spring Creek and the unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in the Wichita River at station A-2 and the mean Spring Creek and ZZ flows.

No known point sources impacted Lake Diversion during the sampling year.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

D. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Wichita River	3,745	81.9
Spring Creek	120	2.6
b. Minor tributaries & immediate drainage (non-point load) -	435	9.5
c. Known municipal STP's - None	-	-
d. Septic tanks* -	40	0.9
e. Known industrial - None	-	-
f. Direct precipitation** -	240	5.2
Total	4,580	100.0

2. Outputs -

Lake outlet -	South Side Canal	2,085
	Wichita River	1,490
	Total	3,575

3. Net annual P accumulation - 1,005 kg.

* Estimate based on 130 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Wichita River	88,920	76.1
Spring Creek	2,830	2.4
b. Minor tributaries & immediate drainage (non-point load) -	10,305	8.7
c. Known municipal STP's - None	-	-
d. Septic tanks* -	1,470	1.2
e. Known industrial - None	-	-
f. Direct precipitation** -	14,940	12.6
Total	118,465	100.0

2. Outputs -

Lake outlet - South Side Canal	49,270	
Wichita River	41,820	
Total	91,090	

3. Net annual N accumulation - 27,375 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Wichita River	<1	16

* Estimate based on 138 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.33	0.07	8.6	2.0

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake Diversion at normal pool level:

"Dangerous" (eutrophic loading)	0.56
"Permissible" (oligotrophic loading)	0.28

V. LITERATURE REVIEWED

Gamble, Robert B., 1974. Fishery management recommendations. Fed. Aid Proj. F-4-R-21, TX Parks & Wildlife Dept., Austin.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKING

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500- MEAN SEC	MEAN CHLORA	15- MIN DO	MEDIAN DISS ORTHO P
4801	AMISTAD LAKE	0.013	[illegible]	[illegible]	[illegible]	14.400	[illegible]
4802	BASTROP LAKE	0.027	0.090	474.917	12.392	15.000	0.007
4803	BELTON RESERVOIR	0.020	0.145	376.312	8.625	15.000	0.007
4804	BRAUNIG LAKE	0.134	0.150	461.625	20.792	14.000	0.092
4805	BROWNWOOD LAKE	0.027	0.100	470.375	4.807	14.400	0.007
4806	LAKE BUCHANAN	0.036	0.250	437.625	8.400	15.000	0.032
4807	CADDO LAKE	0.055	0.070	463.333	14.800	11.400	0.011
4808	CALAVERAS LAKE	0.030	0.040	461.667	20.500	13.000	0.007
4809	CANYON RESERVOIR	0.010	0.450	384.222	2.500	14.000	0.006
4810	LAKE COLORADO CITY	0.042	0.090	473.625	12.675	10.200	0.012
4811	CORPUS CHRISTI LAKE	0.112	0.130	475.167	19.756	14.000	0.050
4812	SOMERVILLE LAKE	0.025	0.080	478.111	15.067	9.400	0.009
4813	EAGLE MOUNTAIN LAKE	0.024	0.070	469.625	5.082	11.000	0.006
4814	FT PHANTOM HILL LAKE	0.040	0.105	476.909	6.317	9.400	0.021
4815	GARZA LITTLE ELM RESERVO	0.046	0.380	475.792	14.250	14.000	0.030
4816	KEMP LAKE	0.023	0.110	455.000	18.237	10.400	0.007
4817	HOUSTON LAKE	0.097	0.290	486.187	16.650	12.400	0.036
4818	LAKE OF THE PINES	0.031	0.090	448.000	12.919	15.000	0.011
4819	LAVON RESERVOIR	0.063	0.190	485.333	5.400	6.000	0.020
4820	LIVINGSTON LAKE	0.196	0.555	485.400	16.112	15.000	0.129
4821	LYNDON B JOHNSON LAKE	0.042	0.420	436.500	8.100	14.900	0.013
4822	MEDINA LAKE	0.010	0.600	413.562	12.944	15.000	0.004
4823	LAKE MEREDITH	0.021	0.070	434.312	3.037	14.400	0.009
4824	PALESTINE LAKE	0.031	0.100	442.625	10.619	14.000	0.010
4825	POSSUM KINGDOM RESERVOIR	0.023	0.070	474.045	9.465	15.000	0.009
4826	SAN ANGELO RESERVOIR	0.094	0.140	481.000	34.675	10.200	0.031
4827	SAM RAYBURN RESERVOIR	0.025	0.150	435.400	6.267	15.000	0.009
4828	E V SPENCE RESERVOIR	0.036	0.080	462.583	11.775	15.000	0.006

LAKE Data TO BE USED IN Rankings

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	[illegible] SEC	[illegible] CHLPH	[illegible]	[illegible]
425	SOMERVILLE LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
430	STAMFORD LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
431	STILLHOUSE HOLLOW RESER	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
432	TAWAKONI LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
433	TEXARKANA LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
434	TEXOMA LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
435	TRAVIS LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
436	TYCHOSO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
437	TWIN BUTTES RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
438	WHITE KING RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
439	WHITNEY LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PERCENT OF LAKES WITH HIGHER VALUES NUMBER OF LAKES WITH HIGHER VALUES

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	[illegible] SEC	[illegible] CHLA	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAKE [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAKE [illegible] CITY	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	EAGLE [illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	FT PHANTOM [illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LITTLE ELM RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAKE OF THE PINES	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] & JOHNSON LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAKE [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	PALESTINE LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] [illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	SAN [illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	SAN [illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	E V SPENCE RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PERCENT OF LAKES WITH HIGHER VALUES | NUMBER OF LAKES WITH HIGHER VALUES

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	[illegible] SEC.	[illegible] CHLOR	[illegible] ASH 10	[illegible] DISS [illegible]	[illegible] 60
[illegible]	SOMERVILLE LAKE	29 (141)	55 (233)	24 (96)	3 (12)	67 (257)	38 (160)	204
[illegible]	STAMFORD LAKE	18 (73)	67 (277)	5 (23)	18 (73)	82 (337)	39 (161)	256
[illegible]	STILLHOUSE HOLLOW RESERV	68 (333)	37 (144)	67 (333)	92 (356)	17 (61)	54 (199)	372
[illegible]	TAMINA LAKE	32 (125)	78 (269)	37 (140)	21 (80)	63 (244)	38 (160)	253
[illegible]	TEXARKANA LAKE	11 (46)	51 (196)	13 (59)	16 (69)	72 (277)	13 (54)	176
[illegible]	TEXOMA LAKE	39 (163)	34 (129)	61 (233)	45 (177)	17 (69)	21 (79)	217
[illegible]	TRAVIS LAKE	68 (339)	21 (79)	92 (356)	82 (333)	17 (61)	6 (35)	384
[illegible]	TWIN BUTTES RESERVOIR	8 (30)	61 (229)	11 (46)	5 (23)	92 (365)	8 (30)	369
[illegible]	WHITE KING RESERVOIR	59 (229)	21 (79)	58 (229)	61 (229)	49 (179)	63 (237)	321
[illegible]	WHITNEY LAKE	94 (383)	61 (229)	76 (289)	89 (344)	17 (69)	63 (237)	348
[illegible]	[illegible]	63 (264)	51 (196)	79 (383)	71 (277)	17 (69)	76 (289)	357

[illegible] RANKED BY [illegible] INDEX [illegible]

RANK	LAKE CODE	LAKE NAME	[illegible] INDEX
1	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]

[illegible] NAMED BY [illegible] NO.

[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	239
30	[illegible]	[illegible]	257
31	[illegible]	[illegible]	264
32	[illegible]	[illegible]	268
33	[illegible]	[illegible]	276
34	[illegible]	[illegible]	272
35	[illegible]	[illegible]	284
36	[illegible]	[illegible]	259
37	[illegible]	[illegible]	255
38	[illegible]	[illegible]	239
39	[illegible]	[illegible]	16

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lb_s/square mile

APPENDIX C

TRIBUTARY FLOW DATA

[illegible]

APPENDIX D

PHYSICAL and CHEMICAL DATA

[illegible]

[illegible]

APPENDIX E

TRIBUTARY DATA

[redacted]

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]
[illegible]